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This report describes three studies designed to predict performance in Explosive Ordnance Disposal (EOD) training. The general purpose of the research was to develop valid measures that could be used to identify qualified candidates and reduce attrition created by recruiting inappropriate personnel. The first study investigates psychological factors underlying successful completion of a 42 week training course. The second study identifies physical performance predictors of success in a preconditioning training (Over)

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program. The third study investigates both psychological and physical factors associated with completion of a 12 week Diver Second Class course. All studies used criterion-related validation strategies. Personnel selection test batteries were developed as a result of each study. Recommendations for test use by all services as well as specific measures for diver selection are discussed.

PSYCHOLOGICAL AND PHYSICAL PERFORMANCE FACTORS ASSOCIATED WITH ATTRITION IN EXPLOSIVE ORDNANCE DISPOSAL TRAINING

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March 1984

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Abstract

This report describes three studies designed to predict performance in Explosive Ordnance Disposal (EOD) training. The general purpose of the research was to develop valid measures that could be used to identify qualified candidates and reduce attrition created by recruiting inappropriate personnel. The first study investigates psychological factors underlying successful completion of a 42 week training course. The second study identifies physical performance predictors of success in a preconditioning training program. The third study investigates both psychological and physical factors associated with completion of a 12 week Diver Second Class course. All studies used criterion-related validation strategies. Personnel selection test batteries were developed as a result of each study. Recommendations for test use by all services as well as specific measures for diver selection are discussed.

I. Introduction

Personnel attrition during training continues to be a major barrier to developing an adequate supply of qualified Explosive Ordnance Disposal (EOD) technicians in the Armed Forces. Moreover, the Navy's requirements for EOD personnel place unique demands on student training, and this makes the retention of qualified individuals even more important. By any standard, Navy EOD training is intensive, lengthy, and academically demanding. Historically, the program has tried to recruit petty officers on their second enlistment in order to identify mature and dedicated candidates. There are now fewer of these individuals than there were in the past, and this has increased the numbers of E1s and E2s entering the program. As might be expected, attrition rates have soared by adding these ranks and the manpower requirements for qualified EOD technicians are not being met.

The purpose of the research described in this report is to develop a means through which attrition in EOD training can be reduced. The research began by identifying those portions of the training program producing the highest attrition rates (Quigley & Hogan, 1982). Over the past two years our research has focused on developing methods to improve student personnel selection. The goal here is to provide the EOD community with valid selection procedures that will identify persons with the motivational, academic, and physical qualifications relevant for this training. This second phase of the research is described in this report.

The overall project is organized in a series of cross-sectional and longitudinal studies. The results presented are either from ongoing research or research that will require subsequent cross validation. We have organized our findings in terms of three studies whose sample sizes

are now sufficient to allow meaningful interpretations. The first study identifies psychological predictors of success in EOD training in a cross-sectional analysis. The second study identifies physical measures associated with completion of a preconditioning physical training program. The last study analyzes physical and psychological predictors associated with successful completion of training leading to second class diving and scuba certification. These three studies are interrelated; the goal is to provide a comprehensive set of selection procedures and recommendations for use in recruiting potential EOD candidates.

II. Overview of Explosive Ordnance Disposal (EOD) Training

The EOD mission is to handle incidents involving explosive ordnance that pose real or potential threats to operations, installations, personnel, and/or material. Within each Service, EOD personnel are responsible operationally for carrying out the mission on specified installations and in assigned geographic areas. In addition EOD personnel provide support to civil authorities when dangerous articles are reported in areas outside DOD installations. Such assistance may be either action or advice but it is rendered by request from a federal or civil agency when required in the interest of public safety.

Training of EOD technicians is a joint services responsibility; one school provides technical training for all military personnel enrolled in EOD training. Some portions of training are conducted at various locations (e.g. Redstone Arsenal, Huntsville, AL.), but most is conducted by the Naval School, Explosive Ordnance Disposal at Indian Head, MD. The school is staffed with instructors from each service and each is also represented by liaison officers. Responsibility for training ultimately rests with the commanding officer of the Naval School.

The EOD training program conducted at the Naval School consists of a common core of courses for all Services as well as specialized courses required by individual Services. Navy personnel volunteer for a 42 week course sequence beginning with diving training and concluding with nuclear ordnance. The curriculum also includes courses in chemical/biological agents, core block (principles, explosives, fuses, effects, etc.), ground and projectile ordnance, demolition, air ordnance, underwater ordnance, and improvised explosive devices. Technical material is normally taught using both classroom lectures and field exercises. Students are evaluated

on the basis of their understanding of course content as well as their ability to solve field problems. These evaluations allow a student to pass or repeat a course (rollback). Successive rollbacks can result in academic dismissal. Other instances where students do not complete a course are termed medical or administrative drops or voluntary withdrawals.

This course of training is among the most academically demanding in the Armed Services. Successful course completion depends on cognitive, psychological, motivational, and vocational interest factors. In addition, Navy personnel must maintain a high level of physical fitness in order to complete the diving and underwater ordnance phase. It should, therefore, come as no surprise that student attrition is a problem. The importance of the job and the rigor of the training program highlight the need for studying and alleviating sources of attrition in the program.

III. A Cross-Sectional Analysis of Factors Associated with EOD Academic Performance

This study investigates the parameters of academic performance in a sample (N=196) of EOD students enrolled in the 42 week training program at the Naval School, Indian Head, MD. Specifically, the study was designed to identify crucial non-cognitive predictors of performance in technical training, an aspect of selection rather neglected in military testing. This first study uses a cross-sectional design, and is therefore a concurrent analysis of psychological factors associated with performance in EOD training.

The Concept of Non-Technical Performance

We emphasize noncognitive predictors of performance in part because, in populations such as that undergoing EOD training, the variance in scores on cognitive measures will be quite restricted. Given this restricted variance, it becomes important to look for predictors that are less constrained. In addition to such psychometric considerations, however, we are philosophically committed to the view that the non-technical aspects of every job are as crucial to overall performance as the technical aspects (cf. Hogan, Carpenter, Briggs & Hansson, 1984). An everyday example is a gifted athlete who won't train and can't be coached; such a person, despite outstanding technical skills, will normally be a liability rather than an asset to his or her team.

In the same way, in most spheres of everyday performance, such non-technical characteratics as conscientiousness, achievement motivation, leadership ability, and cooperativeness are very important. Indeed, they are often more important than sheer technical competency. We have assembled a battery to assess these non-technical factors, and it will be

described below. This battery provides parsimonious but comprehensive coverage of the most important of these non-technical factors, using the most carefully developed and fully validated testing devices presently available.

Method

In April 1982, all enlisted personnel enrolled at the EOD school completed an extensive test battery to be described below. This sample was a cross-section of students from all Services at the school; they were in various phases of their training--i.e., some were just beginning, some were midway, some were almost finished. Students were then followed to the end of the program. Three criterion scores were recorded for each student: (1) whether or not they finished the program (Completion); (2) final grade point average at the end of the entire course (Final Average); and final class rank (Class Standing). Other data show that attrition at the Naval School tends to occur early, and averages about 52% of all those entering the school. The criterion of finishing the program is therefore less than adequate because not everyone in the cross-sectional sample is equally free to attrite. Our records suggest a further complexity in this criteron index. About 30% of attrition in the Navy EOD program is due to academic failure, but 40% occurs during the diving phase of training (Quigley & Hogan, 1982). Our completion criterion, therefore, combines academic failure with unsatisfactory diving performance for Navy students. In psychometric terms, one could regard this criterion as less reliable than Final Average, and therefore, it should be less efficiently predicted.

The predictor battery included the following four procedures: the California Psychological Inventory (CPI; Gough, 1975); the Hogan Personality Inventory (HPI; Hogan, 1983, 1984); the Self-Directed Search (SDS, a vocational preference measure--Holland, 1972); and the Armed Services Vocational Aptitude Battery (ASVAB; U.S. Department of Defense, 1980). The CPI is one of the most fully validated measures of normal personality ever developed. The HPI assesses six factors associated with status and popularity in everyday life; those are: Intellectance (bright vs. dull); Adjustment (high vs. low self-esteem); Prudence (conscientious vs. irresponsible); Ambition (energetic and leaderlike vs. anergic and weak); Sociability (extraverted vs. introverted); and Likeability (agreeable vs. disagreeable). The SDS is recognized as the standard vocational preference battery used in the country today. The ASVAB is the primary cognitive battery used by the Armed Forces. Our own analyses revealed this to be an extremely inefficient measure; for the purposes of these analyses we used only two subscales--Word Knowledge and Arithmetic Reasoning.

Results

Our first set of results concerns the characteristics of the average EOD trainee. On Holland's SDS, EOD divers received their highest scores on Realistic, Investigative, and Social interests. This is the profile of an engineer, a technician, or perhaps an athlete. Such persons are practical, concrete, technically oriented, and masculine. They are also curious, helpful, and well-coordinated. It follows that persons who deviate markedly from this profile (i.e., persons with Artistic and Conventional interests) will be unhappy during EOD training and at risk for attrition. On the CPI, EOD students received high scores for Social

Presence, Self Acceptance, and Psychological Mindedness, and low scores for Responsibility, Socialization, and Communality. Such persons are well-adjusted, self-assured, unconventional, and curious. A similar profile would be found for race car drivers, pilots, and professional athletes; in short, these divers are, as a group, bright, masculine, and rambunctious.

Table 1 presents the second set of results concerning the predictors of academic performance during EOD training. On the CPI, six scales were significantly correlated with one of the criterion measures. These were: Responsibility, Socialization, Tolerance, Good Impression, Achievement via Independence, and Managerial Potential. The correlations were modest; they varied between .14 and .22. Nonetheless, they are interpretable and suggest that academic performance, as assessed by the CPI, is a function of being bright, dutiful, and conforming.

The correlations at the bottom of Table 2 amplify and extend these conclusions. Specifically, correlations with the HPI show that academic performance involves elements of leadership and introversion (Ambition and Low Sociability) as well as intellectual interests (Intellectance). Brightness, leadership, and conformity are the themes reflected by correlations with the SDS. Finally, correlations with the ASVAB (Table 1) provide additional support for the brightness dimension.

The primary scales of the HPI can be decomposed into small units called Homogenous Item Composites (HICs), and analyses can be run at the HIC level as well as the scale level. Correlations between Completion, Final Average, Class Standing, and the HICs of the HPI also reveal the theme of brightness, leadership ability and introversion, and these are presented in Table 2.

Table 1

Correlations of CPI, SDS, and ASVAB Scales with Criterion Measures of Diving Phase Performance

Scale	Completion	Final Average	Class Standing
California Psychological Inventory (N=85-143)			
Dominance	.03	.05	-.10
Capacity for Status	.07	.01	.01
Sociability	-.02	-.03	.05
Social Presence	-.06	-.06	.12
Self Acceptance	.04	-.02	-.02
Sense of Well-being	.05	-.01	.02
Responsibility	.10	.14*	-.15
Socialization	.04	.14*	-.14
Self Control	.03	-.01	.07
Tolerance	.17*	.01	.05
Good Impression	-.04	-.11	.22*
Communality	.04	.07	-.17
Achievement via Conformance	.08	.12	-.13
Achievement via Independence	.20**	.12	-.07
Intellectual Efficiency	.09	.13	-.12
Psychological-mindedness	-.03	.10	.02
Flexibility	-.04	.02	.11
Femininity	-.05	.09	-.06
Managerial Potential	.14*	.02	-.02
Worker Orientation	.10	-.03	.03
Self Directed Search (N=105-167)			
Realistic	.09	-.05	-.08
Investigative	.17*	.17*	-.18*
Artistic	.01	.06	-.14
Social	.08	.04	-.01
Enterprising	.17*	.15*	-.21**
Conventional	.14*	.19**	-.19*
ASVAB (N=27-89)			
Word Knowledge	-.04	.23*	-.18
Arithematic Reasoning	.00	.19	.16
Combined Score	.08	.34**	-.17

*p ≤ .05
**p ≤ .01

Table 2

Correlations of HPI HICs and Scales

with Criterion Measures of School Performances

HIC	Completion	Average	Standing
Good Memory	.17**	.07	-.08
School Success	.14*	.26**	-.23**
Math Ability	.07	.06	-.05
Science Ability	.14*	.11	-.17*
Reading	.17**	.22**	-.20*
Cultural Taste	.11	.04	.06
Curiosity	.11	-.02	-.11
Intellectual Games	.08	-.02	-.04
Generates Ideas	.01	.07	-.11
Not Anxious	-.05	-.04	.03
No Social Anxiety	-.02	-.02	.00
No Guilt	-.01	-.08	.11
Not Depressed	-.05	-.08	.11
No Somatic Complaints	.00	.03	-.11
Calmness	-.08	.11	-.09
Self-Confidence	.02	-.04	.03
Identity	.00	-.16*	.07
Good Attachment	.02	-.02	.04
Structure/Planfulness	.03	.01	-.18*
Not Spontaneous	.13*	.07	-.14
Impulse Control	-.02	-.07	-.01
Avoids Trouble	.04	.17**	-.04
Experience Seeking	-.10	.05	-.07
Thrill Seeking	-.12*	.03	.06
Leadership	.09	.17**	-.19*
Mastery/Hard Work	.03	.00	-.04
Competitive	-.06	.10	-.16*
Impression Management	.08	.07	-.21**
Appearance	-.10	-.08	-.08
Autonomy	-.06	-.03	-.05
Easy to Live With	-.10	.03	-.04
Even Tempered	-.05	-.05	.11
Caring	-.05	-.09	.18*
Trusting	.08	.04	.02
Entertaining	.06	-.02	.06
Likes Crowds	-.03	-.23**	.20*
Exhibitionistic	.04	.02	.02
Likes Parties	-.06	-.07	.16*
Likes People	-.05	-.14*	.20*
Expressive	-.12*	-.09	.15
Self-Focus	-.11	-.13*	.09
Perfect	.01	-.02	.00
Infrequent Response	.09	-.04	.05
Scales			
Intellectance	.21**	.18**	-.20*
Adjustment	-.06	-.10	.06
Prudence	-.03	.02	-.05
Ambition	.07	.10	-.26**
Sociability	-.05	-.13*	.20*
Likeability	-.05	-.06	.13

*$p < .05$

**$p < .01$

Contrary to our prediction and as Tables 1 and 2 show, the Completion criterion was as predictable as Final Average. Correlations with this criterion are, however, slightly smaller, on the whole, than correlations with Final Average. It is worth noting that, although the correlations are slightly smaller, precisely the same themes appear here as in the earlier analysis. Bright, self-confident, conforming students are the ones most likely to survive in this rigorous and lengthy training program. The reader should also note that, with Class Standing, higher scores mean poorer performance. The signs of the correlations are in the expected direction.

The pattern of HPI correlations with the three criterion measures show a consistent relationship with the Intellectance scale. Two additional HICs from the Sociability scale are related to both Final Average and Class Standing. These HICs, Likes Crowds and Likes People, were inversely related to the criterion which indicates that a lack of interpersonal interests and a tendency toward introversion are associated with better performance. The Intellectance scale plus the two Sociability HICs were combined into a single scale called "EOD Performance Index" (See Appendix A). This 58 item scale was correlated with the Completion, Final Average, and Class Standing criteria and these coefficients were .24, .25, and -.24 (all $p < .01$), respectively. This scale summarizes our HPI findings and was used in subsequent analyses.

The third set of results consists of regression analyses designed to predict the three dependent criteria. A stepwise multiple regression analysis (Hull & Nie, 1981) comparing all predictor variables with the Completion criterion resulted in a multiple R of .34; the EOD Performance Index entered on the first step, the Achievement via Independence and

Psychological Mindedness scales of the CPI entered on the second and third steps, and the Enterprising Scale of the SDS entered on the final step. Regression analysis comparing the predictor battery with the Final Average criterion yielded a multiple R of .32, with the EOD Performance Index, the composite score of the ASVAB, and the conventional Scale of the SDS entering the equation. Finally a multiple R of .28 resulted from stepwise regression of the predictor battery with Class Standing. The EOD Performance Index entered as the first step and the Good Impression scale of the CPI entered as the second.

Discussion

There are four points about these analyses that we would like to emphasize. The first concerns the kind of person who is likely to persist to completion of this program. These people are intellectually motivated, self-assured, self-confident, and conforming. This suggests that persons who are uninterested in technology, self-effacing, and non-conforming are poor risks for EOD training.

Our second point concerns the use of vocational preference measures in practical selection contexts. Many people seem unaware of the potential of these measures, but we have found in our research that they typically work well (cf. Johnson & Hogan, 1981). An examination of Table 1 shows that the SDS works reasonably well in these analyses, too.

Our third point concerns the relative merits of cognitive versus noncognitive measures as predictors of academic performance. As Table 1 shows, the non-cognitive measures are easily comparable to the ASVAB in terms of predicting performance in EOD training. When we turn to the bottom line, persistence to completion of the program, the ASVAB (a perfectly representative cognitive measure) is seen to be without utility.

(For an extended treatment of this, see Hogan, Carpenter, Briggs, & Hansson, 1984). The traditional obsession of the psychometric establishment with cognitive measures to the exclusion of other obviously important variables may have to change.

Our final point is that, although the correlations with performance in training are only in the .30 range, this is respectable given the unknown but necessarily poor reliability of our criterion measures. These .30 correlations represent the lower bound on the predictive validity of our EOD battery in this sample. Thus, .30 should not overestimate the cross-validated validity of these predictors.

IV. Physical Performance Analyses of Pre-conditioning Training

Navy EOD training has a substantial physical performance component. The Navy course includes a three-week preconditioning training phase followed by diver training and underwater ordnance phases. The goal of the preconditioning training is to insure a level of physical fitness that will enable students to complete subsequent diver training without undue stress and fatigue. The preconditioning and diver training phases account for 70% of the total attrition in the entire Navy EOD course (Quigley & Hogan, 1982). The purpose of this second study was to examine the physical performance factors associated with attrition in EOD preconditioning training and develop a physical test battery for selecting future candidates. Therefore, we conducted a predictive, criterion-related study of physical tests that could be used for future personnel selection.

Although there are a number of physical tests that one can use, we formed our experimental test battery using a conceptual model of human performance. Even a cursory literature review turns up a wide array of concepts and categories of physical performance, many of which are overlapping, derivitive, and/or highly specific. Existing physical performance test batteries and their dimensionality were developed either through factor analytic techniques (Fleishman, 1964; Harris, 1969; Jackson, 1971), or rational evaluation of human work and fitness capacity (Baumgartner & Jackson, 1982). Fleishman (1979) proposed that nine basic physical abilities, identified as components of physical proficiency, can be used to evaluate the physical abilities required in job performance. This taxonomy, however, suffers from definitional and measurement

inconsistencies. These factorially-derived categories must be merged with physiological definitions in order to provide a standard and comprehensive set of dimensions for the study of occupational performance.

We identified seven dimensions that provide a comprehensive coverage of the physical performance domain using the following four criteria. (1) recognized research history as a component of a relevant taxonomy; (2) definition consistent with human physiological categories; (3) measurement yielding adequate variability across individuals; (4) potential to account for variability in performance of multiple tasks. We have used these seven physical performance dimensions to study job requirements and develop selection tests for a range of occupations in industry (Hogan & Bane, 1983; Hogan, Pederson, & Zonderman, 1981). These dimensions and their definitions are discussed next.

Physical Performance Constructs

Muscular Strength. Muscular strength is the capacity to exert force as the result of tension produced in the muscle in a single maximal contraction. (Clarke, 1966, p. 4). In an applied work sense, muscular strength is the capacity to exert force against a resistance for a brief period of time. Muscular strength as a taxonomic category is recognized by virtually all exercise and work physiologists (e.g. Astrand & Rodahl, 1977; deVries, 1980). Static and dynamic strength are major sub-categories of this dimension. Differences between static and dynamic muscular strength are seen at the level of the internal muscle state and at the output level. Furthermore, both static and dynamic muscular strength can be used in several different ways, with specific measurement techniques corresponding to the kind of use. Because static and dynamic strength are typically required by the same tasks in applied work settings

and because correlations between the two are relatively high, we collapsed across the distinction for this project. The definition of muscular strength used in this research was "exerting muscular force against resistance."

<u>Muscular Power</u>. Muscular power is the capacity to exert the force required to move a mass a given distance during a measured time. Muscular power encompasses the dynamic aspect of muscular strength and includes a speed component not required for the definition of muscular strength (O'Connell & Gardner, 1972, p. 83). Although Wilmore (1977) subdivides power into explosive or ballistic power and general power, it appears that general power is sufficiently explicit for use in applied settings. Moreover, the ballistic power responsible for initiating limb movement would be included in the assessment of general power. For purposes of construct analysis in this research, muscular power was defined as "exerting muscular force quickly or in bursts."

<u>Muscular Endurance</u>. Muscular endurance is the capacity of the muscles to continue work over time while resisting fatigue (Clarke, 1966, p. 4). The conditions resulting in requirements for muscular endurance involve continual or repeated applications of muscular strength (static, dynamic, or both) and/or muscular power. Tasks requiring muscular endurance may involve moving or maintaining weights external to the body or moving or supporting one's own body weight. Although some definitions specify that muscular activity continues to exhaustion (cf. Baumgartner & Jackson, 1982), this rarely occurs in occupation tasks. Therefore, our definition is limited to persistance in demanding physical activity. This construct deals with repeated or continual demands placed upon the musculoskeletal system only; it does not apply to cardiovascular endurance

(see cardiovascular endurance below), which may or may not occur in conjunction with the activities requiring muscular endurance. The definition of muscular endurance for this research was stated as "resistance to muscular fatigue."

Cardiovascular Endurance. Cardiovascular endurance refers to the capacity of the heart and related body systems, particularly the vascular and respiratory systems, to sustain prolonged muscular activity. In contrast with muscular endurance, which involves a limited group of muscles and joints, cardiovascular endurance is concerned with the general capacity of the cardiovascular system to support a given amount of physical work. Terms such as "physical fitness," "stamina," and "endurance" have become synonymous with cardiovascular endurance. The definition used for construct analysis in this research was "resistance to overall fatigue that would occur when body systems (heart, lungs, muscle, etc.) are placed under stress."

Flexibility. The physiological definition of flexibility is the full range of motion through which a limb or limb segment can rotate; that is, the measure of the greatest arc through which a limb or limb segment is able to travel in a given plane (for some applications, measurements may be taken in more than a single plane). In addition to the degrees of limb movement that the joint allows, which can be termed static flexibility, the speed with which the motion can be accomplished may be considered an aspect of dynamic flexibility (deVries, 1980). The ease with which a joint can displace a lever (limb segment) is an important facet of skilled physical performance. Although range of motion and speed of movement of individual joints are critical factors underlying work performance, a concept of multiple joint flexibility is needed to define the degree to

which the multiple levers of the body can be displaced for accomplishing work. This view is strongly supported by Harris (1969) whose factor-analytic work shows that flexibility is highly specific, that no single joint or composite measure is a satisfactory index of overall flexibility. The definition of flexibility used for construct analysis in this research covers flexibility demands on a single or multiple joints with "bending or stretching the body or limbs."

Balance. Balance is defined as maintaining body stability. O'Connell and Garnder (1972) categorize the conditions under which an individual maintains balance as either static or dynamic. Balance under static conditions requires maintaining stability while in a posture or body position. This includes maintaining a pose against outside forces. Balance under dynamic conditions occurs during active physical performance. In balancing, the center of gravity must be adjusted, and coordinated with shifts in the base of support. This depends on forces generated by the body as well as by inertia. When the center of gravity does not remain over the base of support, instability results and balance is lost. The construct of balance in the present model incorporates both static and dynamic equilibrium with "exerting effort in order to maintain the body in a stable position." Resisting forces to maintain body stability when in a stationary posture or when in motion both occur during physical performance.

Neuromuscular Coordination. Coordination concerns organizing movements in sequence within required temporal and spatial constraints in response to either internal or external stimuli. Fleishman (1953) identified a psychomotor coordination factor in his early research that serves as a basis for the present concept. He describes this factor as

"...either integrating muscular movements or coordinating between the eye and muscular movements" (p. 248). In the field of motor learning and motor control, this construct might be termed anticipatory timing to external cues such as projectiles and displays (Helson, 1949); it may also be self-initiated and dependent on internal cues as, for example, during diving, or cycling (Schmidt, 1971). Movement sequences can involve arms and legs separately or combined, as well as limbs moving while the body is in motion or stationary. Moreover, the coordinated sequences of motion can involve movement of a single joint or total body and multi-limb activities. Coordination is primarily concerned, not with the extent of limb and joint involvement, but with the spatial and temporal requirements that determine accurate and effective performances. Neuromuscular coordination was defined as "precision to sequencing movements involving the arms, legs, and/or body."

Selection of Tests

We reviewed numerous physical tests and measures as candidates for the experimental predictor battery. Five criteria were used for test se[illegible]n. They were: (1) resemblance to the constructs listed above; (2) ease of administration; (3) reliability; (4) availability of normative data; and (5) recognized research history in performance assessment. We reviewed physical performance assessment literature in physical education, sports and athletics, physical and health fitness, occupational performance and exercise and work physiology. We paid special attention to factor analytic studies of physical fitness because we were interested in both construct validity and parsimonious coverage of the physical performance domain (see, for example, Baumgartner & Zuidema, 1972; Falls, Ismail, McLeod, Weibers, Christian & Kessler, 1965; Fleishman, 1964;

Harris, 1969; Ismail, Falls & McLeod, 1965; Jackson, 1971; Zuidema & Baumgartner, 1974).

Measures from five widely known physical fitness test batteries--AAHPERD (1976) Youth Fitness Test, AAHPERD (1980) Health Related Fitness Test, Cooper's (1968) field test of aerobic capacity, Fleishman's (1964) Basic Fitness Tests, and the ICSPFT (1974) Basic Physical Performance Tests--satisfied most of the criteria outlined above. These tests, the batteries from which they were drawn, and the physical performance dimension intended to be measured appear in Figure 1. We included some additional tests in the battery on the basis of their previous success in test validation research.

Beyond the tests representing the seven physical performance dimensions, three anthropometric measures and a manual dexterity test were included. The anthropometric measures were height, weight, and skinfold. Skinfold measures were assessed using electronic calipers (Skyndex; Skyndex Corporation) programmed to calculate percent body fat based on the Durnin formula (Durnin & Womersly, 1974). This formula correlates significantly with underwater weighing results and it seems more accurate than the Sloan (Sloan, 1967; Sloan, Burt & Blyth, 1962), Jackson-Pollock (Jackson, Pollock & Ward, 1978), and Brozeck-Keys (Brozeck, Grande, Anderson & Keys, 1963) formulae which tend to underestimate body fat by 3 to 4%. The manual dexterity measure chosen was the Purdue Pegboard (Tiffin, 1960), chosen on the basis of its popularity and extensive normative data.

Method

Predictors. Twenty-six tests--23 performance tests and 3 anthropometric measures--composed the experimental battery. Measures from

Figure 1

Physical Performance Dimensions, Definitions, and Tests

Physical Performance Dimension	Physical Tests
Muscular Strength The capacity to exert force as a result of tension produced in muscles	Hand Grip[4,3,5] Static Pull Static Lift
Muscular Power The capacity to exert force to move a mass a given distance during a measured time.	Medicine Ball Throw[4] Shuttle Run[2,4] Standing Long Jump[2] 50 Yd. Dash[2,5] Vertical Jump
Muscular Endurance The capacity of muscles to continue work over time while resisting fatigue	Push Ups Pull Ups[2,4,5] Sit Ups[1,2] Arm Ergometer
Cardiovascular Endurance The capacity of the heart and related body systems to sustain prolonged muscular activity	1 Mile Run[1,5] 1½ Mile Run[3] 600 Yd. Run[2,4,] 300 Yd. Swim Underwater Swim
Flexibility The full range of motion through which a limb, limb segment or lever arm can rotate	Sit and Reach[1] Trunk Twist[4]
Balance The maintenance of body stability	Balance Rail[4] Rolling Board
Neuromuscular Coordination The capacity to organize movements in sequence within temporal and spatial constraints as a response to either internal or external stimuli	Cable Jump[4] Speeded Twist & Bend[4]
Physical Measures	Skinfold[1] Height Weight

[1]American Alliance for Health, Physical Education, Recreation and Dance, (1980). Lifetime health related physical fitness. Reston, VA: AAHPERD.

[2]American Alliance for Health, Physical Education, Recreation and Dance, (1976). Youth fitness test manual. Reston, VA: AAHPERD.

[3]Cooper, K. H. (1968). Aerobics. New York: Bantam Books.

[4]Fleishman, E. A. (1964). The structure and measurement of physical fitness. Englewood Cliffs, NJ: Prentice-Hall.

[5]International Committee for the Standardization of Physical Fitness Tests (1974). Leonard Larson, (Editor). Fitness, health, and work capacity: International standards for assessment. NY: MacMillan.

the five physical fitness test batteries--were included (see Figure 1). Test administration procedures are contained in Appendix B and scoring criteria are presented in Appendix C.

Criteria. We developed nine performance rating scales based on the requirements of the preconditioning training program. The rating scales reflected physical fitness, swimming performance, leadership potential, teamwork, and overall EOD potential. Each rating dimension was defined and a seven-point rating scale was provided. Scale anchors ranged from 1, indicating the student's performance was poor, to 7, indicating superior performance. Three instructors provided independent ratings of each student at the conclusion of preconditioning training.

In addition to the rating scales, an objective index of final status was available. This dichotomous measure indicated whether a student satisfactorily completed physical training or voluntarily withdrew.

Sample. The sample consisted of 46 male Naval personnel who had volunteered for EOD training. Their ages ranged from 20 to 30 years with a mean of 24.5. All volunteered to participate in the physical tests; none received additional compensation.

Procedure. Subjects were tested in small groups of five to seven over a two day period using carefully standardized procedures. Each test administrator was responsible for conducting several tests and subjects rotated among test stations. Subjects completed warm-up exercises prior to testing sessions.

Results

Interrater reliabilities were calculated for the performance rating scales across the three raters and these coefficients ranged from .59 to .84. Scores for each item were correlated, the item matrix was factor

analyzed, and one factor with an eigenvalue of 7.2 accounted for 80% of the variance in the ratings. This factor was defined by overall EOD potential. Subsequent analyses, therefore, included only this rating and course completion status.

Validity Data. Correlations between all physical tests and the two criterion measures are the crucial indices for this analysis. These are presented in Table 3. Two major trends are present in the table. First, tests that purport to measure the same performance dimensions are more highly correlated with each other than with other tests. Second, several physical tests predict criterion evaluations. The cardiovascular endurance tests, particularly the 1-mile run, provide the best overall prediction. The overall EOD potential rating was significantly related to at least one test covering five of the seven physical performance dimensions correlated significantly with ratings for overall EOD potential. Final status was best predicted from cardiovascular endurance, flexibility, and coordination measures.

A stepwise multiple regression was calculated to determine the best combination of tests for predicting final status. A multiple R of .65 was obtained using a test battery consisting of the 1-mile run, sit and reach test, and arm ergometer muscular endurance test. The same three tests yielded a multiple R of .64 with the rating for overall EOD potential. These results are found in Table 4.

Table 5 presents a regression analysis in which the five physical fitness batteries were compared with final status. The six measures of the AAHPERD Youth Fitness Test yielded a multiple R of .51, while the four measures of the AAHPERD health related fitness test produced a multiple R of .48. The nine fitness tests from Fleishman's basic fitness battery achieved a multiple R of .60; cardiovascular endurance, flexibility and

Table 3
Intercorrelations Among Predictor and Criterion Variables

	VARIABLE	SCORE	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1)	1 Mi. Run	Time: Min.	.07	1.00	.36	-.12	-.10	-.20	-.12	-.43	-.30	-.53	-.41	.13	-.29	.29
(2)	1½ Mi. Run	Time: Min.		.07	.19	-.29	-.10	-.25	-.07	-.38	-.50	-.65	-.38	.07	-.38	.22
(3)	600 Yd Run[1]	Time. Min.			.36	-.12	-.19	-.20	-.12	-.43	-.30	-.53	-.41	.13	-.29	.29
(4)	300 Yd. Swim	Time. Min.				.13	.00	.02	-.05	-.01	.22	-.04	-.10	.00	-.12	.27
(5)	Underswim	Distance: Yds.					-.00	.63	.16	.42	.61	.11	.04	.25	.64	.60
(6)	Grip Str.	Force: Kg.						.26	.21	.57	.18	.02	.19	-.25	.10	-.26
(7)	Pull Str.	Force. Lbs.							.29	.61	.39	-.05	.10	.10	.42	.40
(8)	Lift Str.	Force. Lbs.								.33	.08	.02	-.00	.07	.10	.07
(9)	Medicine Ball	Distance: In.									.50	.16	.35	-.00	.50	.06
(10)	Push-up	Absolute No.										.09	.27	.06	.48	.22
(11)	Pull-up	Absolute No.											.26	-.19	.24	-.38
(12)	Arm Ergom.	No. Revolutions/90 Sec.												-.26	.26	-.33
(13)	Shuttle Run	Time: Sec.													-.09	.50
(14)	Long Jump	Distance. In.														.15
(15)	50 Yd. Dash	Time: Sec														

	VARIABLE	SCORE	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
(1)	1 Mi. Run	Time Min.	-.20	-.30	-.01	-.26	-.16	.07	-.02	-.00	-.10	-.20	.17	-.52	-.45
(2)	1½ Mi. Run	Time: Min.	-.20	-.30	-.05	-.35	-.15	.06	-.01	-.02	-.09	-.11	.15	-.37	-.37
(3)	600 Yd. Run[1]	Time Min.	-.20	-.30	-.01	-.26	-.16	.07	-.02	-.00	-.10	-.20	.17	-.52	-.45
(4)	300 Yd Swim	Time Min.	-.04	-.47	.01	-.01	-.22	.13	-.06	-.07	-.00	-.17	.10	-.27	-.32
(5)	Underswim	Distance. Yds.	.26	.10	-.11	.02	.05	.04	.13	-.00	-.15	.02	-.21	.14	.06
(6)	Grip Str.	Force Kg.	.30	-.01	.09	.02	.10	.13	.10	.21	.23	.36	.07	.07	.09
(7)	Pull Str.	Force. Lbs.	.54	.09	-.11	.21	.02	.21	.20	.10	.17	.31	.02	.29	.30
(8)	Lift Str.	Force Lbs.	.35	.13	.21	.29	.03	.18	.15	.09	.03	.30	.02	.24	.16
(9)	Medicine Ball	Distance In.	.62	.07	.12	.11	.20	.07	.24	.20	.11	.39	-.00	.31	.33
(10)	Push-up	Absolute No.	.19	-.02	.27	.31	.26	.15	.10	.10	.04	-.10	-.06	.15	.10
(11)	Pull-up	Absolute No.	.07	.24	.37	.23	.19	-.16	.13	.35	.10	-.05	.01	.22	.32
(12)	Arm Ergom.	No. Revolutions/90 Sec.	.23	.02	.14	.10	.27	.05	.07	.07	.03	.01	-.02	.07	-.05
(13)	Shuttle Run	Time. Sec.	.03	-.14	-.12	-.12	-.32	.03	-.06	-.10	-.16	-.00	-.15	-.25	-.23
(14)	Long Jump	Distance. In.	.35	.30	.03	.07	.20	.08	.09	.09	.01	.07	-.13	.28	.10
(15)	50 Yd. Dash	Time. Sec.	-.06	-.12	-.31	.00	-.00	.16	.09	-.10	-.21	-.00	-.00	-.01	-.00
(16)	Vert. Jump	Distance. In.		-.07	.03	.12	.17	.19	.05	.11	.04	.20	-.14	.23	.17
(17)	Cable Jump	Absolute No.			.02	.30	.01	-.12	.12	.05	-.02	.11	-.06	.27	.34
(18)	Sit-ups	No./60 Sec.				.20	.13	.06	-.08	.13	.26	-.30	.24	.10	.24
(19)	Twist Bend	No./20 Sec.					.22	.37	-.11	-.16	-.07	-.21	-.03	.20	.34
(20)	Sit & Reach	Distance: Cm.						.35	.09	.25	-.23	-.00	-.30	.30	.30
(21)	Trunk Twist	Distance: In.							.15	.06	.12	.04	.15	.22	.20
(22)	Rolling Board	Time. Sec.								.25	.51	.26	.06	.16	.12
(23)	Balance Rail	Time. Sec.									.19	.06	.08	.31	-.00
(24)	Weight	Mass: Lbs.										.17	.00	.00	.09
(25)	Height	Distance: In.											-.06	.23	.17
(26)	Pct/Pat	Percent												-.05	-.05
(27)	Overall Rating														.63
(28)	Final Status														

[1] Derived linearly from 1½ mi. run
Note: Correlations of .24 ($p < .05$) and .31 ($p < .01$) are significant.

Table 4

Regression of Experimental Battery with

Final Status and Overall EOD Performance

Pass/Fail Criterion

Variable	Multiple R	R Square	RSQ Change	Simple R
1-Mile Run	.451	.203	.203	.451
Sit & Reach	.532	.283	.079	-.353
Arm Ergom.	.627	.394	.111	.050

Overall EOD Performance Criterion

Variable	Multiple R	R Square	RSQ Change	Simple R
1-Mile Run	.529	.280	.280	-.529
Sit & Reach	.600	.360	.080	.367
Arm Ergom.	.641	.411	.050	.077

Table 5
Regression of Each Fitness Battery
Final Status

AAHPERD Health Related Fitness Battery:

Variable	Multiple R	R Square	RSQ Change	Simple R
1.5 Mile Run	.370	.137	.137	.370
Sit & Reach	.476	.226	.089	-.353
Sit-ups	.480	.231	.004	-.246
Percent Fat	.482	.232	.001	.059

AAHPERD Youth Fitness Battery:

Variable	Multiple R	R Square	RSQ Change	Simple R
600 Yd. Run	.451	.203	.203	.451
Shuttle Run	.482	.232	.029	.230
50 Yd. Dash	.504	.254	.021	.088
Sit-ups	.512	.262	.007	-.246
Pull-ups	.513	.263	.000	-.228

Fleishman Basic Fitness Tests:

Variable	Multiple R	R Square	RSQ Change	Simple R
600 Yd. Run	.451	.203	.203	.451
Twist & Bend	.510	.261	.057	-.349
Trunk Twist	.532	.283	.022	-.200
Cable Jump	.569	.324	.040	-.345
Shuttle Run	.587	.345	.021	.230
Balance Rail	.594	.353	.008	.009
Sit-ups	.598	.357	.003	-.246
Med. Ball Throw	.600	.360	.003	-.233
Hand Grip	.608	.370	.009	-.099

ICSPFT Battery:

Variable	Multiple R	R Square	RSQ Change	Simple R
1.5 Mile Run	.370	.137	.137	.370
Hand Grip	.375	.140	.003	-.099
Pull-ups	.375	.141	.000	-.228

Cooper Test of Aerobic Capacity:

Variable	Multiple R	R Square	RSQ Change	Simple R
1.5 Mile Run	.370			.370

coordination measures accounted for most of the variance. The only measure from Cooper's Test of Aerobic Capacity used in this research was the 1-1/2 mile run, and it correlated -.37 with Final Status. Finally, four tests of the ICSPFT Basic Physical Performance Tests yielded a multiple R of .38; the best single predictor was the 1-1/2 mile run.

Discussion

Three findings are of interest in this study. The first concerns the relative inefficiency of major test batteries (see Figure 1) to predict performance in a physical conditioning training program. The more comprehensive Fleishman battery is an exception--a substantial amount of variance was explained but at the expense of administering nine tests. This suggests that a broad array of measures is necessary to predict performance in a complex training program. A second unexpected finding is that muscular strength measures did not reliably predict criterion performance. Physical strength measures are typically the core variables for validation research in physically demanding occupations. This lack of relationship may be due to restriction of range: the sample was exclusively male, and strength tests seem not to work well in single sex subgroups. Also worth noting is the lack of validity for height, weight, and skinfold measures. Taken together, these nonsignificant findings for muscular strength and anthropometric measures suggest that successful performance in rigorous physical training is unrelated to physical size. Finally, the consistent pattern of correlations with the cardiovascular endurance tests is inconsistent with the Navy's emphasis on strength tests as predictors of Navy shipboard performance (Robertson, 1982). These results highlight the need for developing a comprehensive conceptual framework in order to adequately understand and predict performance in a wide range of occupational categories.

V. Predictors of Performance in Diver Training

Previous studies indicate that the diving phase of training results in approximately 33% of the total attrition in Navy EOD training. Reasons for this attrition are complex and perhaps obscured by the manner in which attrition is classified. Such classifications as medical, academic and voluntary drop provide little information about the reasons for these actions. The purpose of this study was to identify factors associated with successful completion of the diving phase of EOD training.

Method

We began a longitudinal study of Navy students entering EOD training at Redstone Arsenal in June, 1983. This study is currently ongoing. The predictor battery consists of psychological, cognitive, physical, and manual dexterity tests which are administered immediately after the students report for duty. These tests include the HPI, ASVAB, 24 physical tests (see Appendix B) and the Purdue Pegboard Dexterity Test (see also Appendix B). Students then enter the various phases of EOD training; at this time, data reflecting their training performance is accumulated. The crucial categories are pass, drop, and rollback (repeat the course). A drop is equivalent to failure although the reasons for the drop may be either academic, administrative, or medical.

<u>Sample</u>. The sample consisted of 87 male Navy personnel who had volunteered for EOD training and took part in the testing. Of these students, approximately 69 completed the physical test battery. The sample contained 81 whites and 6 blacks. Their ages ranged from 18 to 34 with a mean of 23.9 years. Rates ranged from E1 to E6 with a high representation of E4s, E5s, and E6s. No subject received additional compensation for participation.

Procedure. After completing consent forms, subjects were given the various tests in a gymnasium and out of doors. All test administration was standardized. Most tests were administered in groups. The paper and pencil tests were given in one hour sessions; each classroom session was followed by physical tests. Students warmed-up prior to taking the physical tests. Using three trained test administrators, all evaluations were completed in approximately one and a half days.

Results

Psychological Tests. The first set of analyses concerned the relationship between personality characteristics (the HPI) and the pass/fail criterion in the diving phase. All students who were still in the program at the conclusion of the diving phase, including rollbacks, were classified as pass; students who left the program for any reason were classified as fail. Table 6 presents the correlations between the HPI (45 HICs and 6 scales)and the pass/fail criterion. Six HICs and the Adjustment scale were significantly correlated with the criterion. These correlations are interpretable and suggest that success in the diving phase of EOD training is a function of being curious, interested in technical matters, well adjusted, and able to work alone.

We wished to combine these results into a single test. Because of the number of predictors (45 HICs) and the modest sample size (N=87), certain precautions were taken to minimize the effects of chance in the data analysis. First, the HICs that comprised this selection instrument were chosen on conceptual grounds. Second, the scale was based on a unit-weighted summation of selected HICs instead of using regression weights that would capitalize on the idiosyncracies of the particular sample.

Table 6

Correlation of HPI HICs and Scales

with Pass/Fail Criterion in Diving Phase

Scale / HIC	Scale / HIC	r	Scale / HIC	r	Scale / HIC	r
Scale	Intellectance	.05	Adjustment	.23*	Prudence	.05
HIC	Good Memory	-.07	Not Anxious	.21*	Good Attachment	-.02
	School Success	.08	No Social Anxiety	.02	Structure/Planfulness	.01
	Math Ability	.07	No Guilt	.21*	Appearance	-.06
	Reading	-.02	Not Depressed	.21*	Mastery/Hard Work	.16
	Science Ability	-.01	No Somatic Complaints	.04	Perfect	-.05
	Cultural Taste	.13	Calmness	.16	Impulse Control	.10
	Curiosity	.25**	Self-Confidence	.08	Avoids Trouble	.04
	Intellectual Games	-.14	Identity	.20*	Experience Seeking	-.03
			Self-Focus	.13	Thrill Seeking	.05
					Not Spontaneous	.09

Scale / HIC	Scale / HIC	r	Scale / HIC	r	Scale / HIC	r
Scale	Ambition	-.08	Sociability	-.17	Likeability	.16
HIC	Generates Ideas	-.07	Entertaining	-.12	Easy to Live with	.14
	Leadership	-.10	Exhibitionistic	-.13	Even Tempered	.12
	Competitive	.10	Likes Crowds	-.16	Caring	-.02
	Status Seeking	-.04	Likes Parties	-.10	Trusting	.10
	Impression Mgmt.	-.01	Expressive	-.03	Likes People	.00
					Autonomy	.19*

*$p < .05$

**$p < .01$

We combined Adjustment with items from the Curiosity and Autonomy HICs to form a single scale. This scale, Diving Phase Performance Index, was then correlated with the pass/fail criterion and the resulting _r_ was .30, ($p < .01$). The Diving Phase Performance Index was used in subsequent analyses. The scale items appear in Appendix D.

The next set of analyses concerned the relationship between the cognitive measure, the ASVAB, and the pass/fail criterion in diving training. We correlated scores on the WK and AR subscales with the criterion for the sample of 87. There were no significant relationships between either ASVAB subscale and success in the diving phase.

Physical Performance Tests. The physical test battery used in the previous study, Section IV, was also used here. Additionally, two measures of the Purdue Pegboard manual dexterity test were obtained. Descriptive statistics were calculated for all measures and these are presented in Table 7. Appendix C lists the calculation procedures and metrics for each of these variables. Correlations between all physical tests are shown in Table 8. These results are similar to those of Table 3. Measures of the same physical construct tend to be more highly related than measures across constructs. Correlations between the 27 physical predictors and the pass/fail criterion are presented in Table 9. Nine of the tests were significantly related to completion of the course, six of which are interpretable. Correlations achieved by both grip strength and the 50 yard dash were significant but the inverse relationship was not predicted. Measures from six of the seven performance constructs significantly predicted success in diving. Only measures from the muscular strength construct were not significant.

Although the best pattern of pass/fail prediction was achieved by the

Table 7

Descriptive Statistics for Physical Performance Tests

Test Name	Unit	$\bar{X}$	S.D.	MIN.	MAX.	N
1.5 Mile Run	Sec.	640.93	72.74	497	884	69
Swim 300	Sec.	392.02	46.13	282	495	45
Undrswim	Yds	26.00	7.88	10	40	20
Mgrip	Kg.	60.09	7.33	48	80	69
Mpull	Lbs.	160.29	25.52	116.67	253.33	69
Mlift	Lbs.	339.67	77.08	27.33	543.33	69
Mmedball	Inch	260.20	40.01	193	422.50	69
Pushup	Number	75.73	47.29	29	409	69
Pullup	Number	12.01	4.96	5	41	69
Ergom	Number	212.36	23.72	165	320	69
Mshuttle	(1/10 Sec.)	107.70	9.25	60	126	69
Mlongjmp	Inch	89.97	58.56	60.33	562.67	69
M50yd	(1/10 Sec.)	37.81	36.05	-17.5	82.5	69
Mvertjmp	(Ft.Lbs/Sec.)	6975.14	1204.92	4741.33	11471.67	69
Cable	Number	4.76	1.69	0	9.0	66
Situps	Number	49.57	9.48	7	66	69
Twistben	Number	16.81	2.72	11	23	69
Sitrch	Cm	35.38	5.64	25.5	51	69
Mtrtwist	Inch	16.33	5.64	0	30	69
MBAroll	(1/10 Sec.)	115.03	257.39	-39.5	1276	69
Mbarail	(1/10 Sec.)	26.54	12.01	12	82.50	69
RBI	Number	47.15	7.50	34	65	69
Assembly	Number	32.15	6.68	11	44	69
Wt.	Lbs.	168.44	41.87	138	486	69
Ht.	(1/10 Sec.)	703.17	36.91	630	935	69
Pctfat	(1/10 %)	164.30	58.09	93	560	69

Table 8

Interrcorrelations Among Physical Test Predictors

	Variable	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1)	1.5 Mile Run	.22	-.09	.03	.19	.00	-.16	-.16	-.31	-.26	-.03	.08	-.09
(2)	300 Yd Swim		-.59	-.04	-.08	-.13	-.20	-.52	-.19	-.08	.09	-.06	-.32
(3)	Underswim			.24	.20	.08	.22	.20	-.02	-.02	-.30	.34	.03
(4)	Grip Str.				.35	.09	.30	.03	-.08	.19	-.23	-.03	-.47
(5)	Pull Str.					-.01	.38	.16	-.03	.19	-.01	.07	-.06
(6)	Lift Str.						.01	-.04	-.14	.00	.04	-.14	.06
(7)	Med. Ball							.61	.44	.45	-.34	.55	-.09
(8)	Push-up								.77	.63	-.52	.07	-.17
(9)	Pull-up									.61	-.52	.73	.03
(10)	Arm Ergom										-.54	.58	-.18
(11)	Shuttle Run											-.66	.47
(12)	Long Jump												-.19
(13)	50 Yd. Dash												
(14)	Vert. Jump												
(15)	Cable Jump												
(16)	Sit-ups												
(17)	Twist Bend												
(18)	Sit & Reach												
(19)	Trunk Twist												
(20)	Balroll												
(21)	Balrail												
(22)	RLB												
(23)	Assem												
(24)	Wt.												
(25)	Ht.												
(26)	Pct. Fat												

	Variable	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
(1)	1.5 Mile Run	-.11	-.10	-.33	-.27	-.05	.08	-.03	.10	-.36	-.04	-.08	.02	.15
(2)	300 Yd Swim	-.14	-.20	-.05	-.29	-.33	-.28	-.42	-.14	-.42	.10	-.08	.02	.15
(3)	Underswim	-.34	.07	.51	.24	-.08	-.04	.46	.06	.19	-.35	.45	-.15	.53
(4)	Grip Str.	.39	.21	.11	-.04	.00	-.04	-.03	.15	-.31	-.10	.21	.43	.05
(5)	Pull Str.	.56	.17	-.03	.13	-.07	.13	.21	-.02	.14	-.14	.24	.41	.05
(6)	Lift Str.	.10	-.20	.02	-.06	.14	.11	-.06	-.01	-.13	-.15	.16	-.12	.16
(7)	Med. Ball	.47	-.07	.16	.01	.08	.11	.16	.13	.16	-.02	.12	.36	-.02
(8)	Push-up	-.08	.03	.28	.07	-.01	-.03	.01	.04	.09	-.24	.21	.43	.05
(9)	Pull-up	-.08	.05	.36	.13	.00	-.19	.06	.11	.04	-.16	.49	.47	.40
(10)	Arm Ergom	.10	.11	.28	.06	.08	-.11	.00	.05	-.08	-.11	.04	.13	-.04
(11)	Shuttle Run	.02	-.26	-.19	-.04	-.18	.06	.07	-.35	.29	.10	-.02	-.18	.00
(12)	Long Jump	-.08	.06	.15	.03	-.06	-.08	-.03	.11	-.06	-.20	-.03	.07	-.01
(13)	50 Yd. Dash	-.02	-.45	-.07	.18	-.02	.09	.20	-.36	.49	.12	.04	-.30	.07
(14)	Vert. Jump		-.10	.04	.05	.08	.19	.04	.16	.01	-.10	.15	.38	-.10
(15)	Cable Jump			.00	.19	.05	.12	.03	.05	-.09	-.03	-.05	.10	-.07
(16)	Sit-ups				.23	.10	.03	-.08	.11	-.01	-.11	.10	-.01	.10
(17)	Twist Bend					.10	.29	-.06	-.02	.37	-.01	-.07	-.13	-.03
(18)	Sit & Reach						.30	.09	.24	.13	.33	-.23	-.11	-.22
(19)	Trunk Twist							.16	.11	.11	.07	.11	.09	.13
(20)	Balroll								.00	.18	-.13	.51	.08	.46
(21)	Balrail									-.14	.07	.08	.06	-.05
(22)	RLB										.28	-.04	-.16	-.02
(23)	Assem											-.42	.05	-.39
(24)	Wt.												.18	.04
(25)	Ht.													-.11
(26)	Pct. Fat													

Table 9

Correlations of Physical Tests
with Pass/Fail Criterion

	RUN 1.5	**SWIM 300**	**UNDERSWIM**	**MGRIP**
PASS/FAIL	-.3193 (69) p=.004	-.1720 (45) p=.129	.2273 (20) p=.168	-.2394 (69) p=.024
	MPULL	**MLIFT**	**MMEDBALL**	**PUSHUP**
PASS/FAIL	.1466 (69) p=.115	.0635 (69) p=.302	.2898 (69) p=.008	.1827 (69) p=.066
	PULLUP	**ERGOM**	**MSHUTTLE**	**MLONGJMP**
PASS/FAIL	.2089 (69) p=.042	.0336 (69) p=.392	.0247 (69) p=.420	.0975 (69) p=.213
	M50YD	**MVERTJMP**	**CABLE**	**SITUPS**
PASS/FAIL	.3490 (69) p=.002	.1586 (69) p=.097	-.1245 (66) p=.160	.2500 (69) p=.019
	TWISTBEN	**SITRCH**	**MTRTWIST**	**MBAROLL**
PASS/FAIL	.1891 (69) p=.060	.1431 (69) p=.120	.2296 (69) p=.029	.2080 (69) p=.043
	MBARAIL	**RLB**	**ASSEMBLY**	**WT**
PASS/FAIL	-.0737 (69) p=.274	.3125 (69) p=.004	.0486 (69) p=.346	.1535 (69) p=.104
	HT	**PCTFAT**		
PASS/FAIL	.0967 (69) p=.215	.0067 (69) p=.478		

muscular and cardiovascular endurance tests, a multiple regression was calculated to determine the optimal combination of all predictors. A multiple R of .58 was obtained using a predictor battery consisting of 1-1/2 mile run, trunk twist, medicine ball throw, underwater swim, 300 yard swim, manual dexterity, and pull-ups. These tests represented coverage of five of the seven performance dimensions from which measures were originally selected.

Table 10 presents regression analyses of specific test batteries included within the overall set of performance measures. These are the same five batteries included and described in Section IV. The dependent variable for all these regressions was the pass/fail criterion. The nine measures of the Fleishman Basic Fitness Tests provided a multiple R of .58 and the AAHPERD Youth Fitness Battery produced a multiple R of .51. The ICSPFT battery, AAHPERD Health Related Fitness Battery, and Cooper Test of Aerobic capacity achieved multiple R's of .41, .38, and .32, respectively.

Table 11 presents multiple regression results for tests of the seven physical constructs used to structure the test battery. Only those tests whose simple correlations were in the appropriate direction were included in the analysis. These measures yielded a multiple R of .51, somewhat lower than the result obtained with the Fleishman tests.

Regression of all Measures. A multiple regression was calculated for independent variables including the HPI, ASVAB, and physical tests with the pass/fail criterion measure. Eight variables entered the equation and yielded a multiple R of .66. These results are presented in Table 12. Six physical tests accounted for 28% of the variance in diving performance; the Diving Phase Performance Index and WK bring the total predicted variance to 43%.

Table VI
Regression of Fitness Batteries with Pass/Fail
in Diving Phase

AAHPERD Health Related Fitness Battery

Variable	Multiple R	RSquare	RSQ Change	Simple r
1.5 Mile Run	.319	.101	.101	-.319
Sit Ups	.353	.125	.023	.249
Sit & Reach	.371	.138	.012	.143
Percent Fat	.375	.141	.003	.006

AAHPERD Youth Fitness Battery

Variable	Multiple R	R Square	RSQ Change	Simple r
50 Yd. Dash	.348	.121	.121	.348
600 Yd. Run	.453	.205	.083	-.319
Sit Ups	.491	.241	.035	.249
Shuttle Run	.506	.256	.015	.024
Pull Ups	.506	.256	.000	.208

Fleishman Basic Fitness Tests

Variable	Multiple R	R Square	RSQ Change	Simple r
600 Yd. Run	.319	.101	.101	-.319
Trunk Twist	.409	.167	.065	.229
Hand Grip	.464	.215	.048	-.239
Med. Ball Throw	.550	.303	.087	.289
Sit Ups	.569	.324	.021	.249
Balance Rail	.575	.331	.006	-.073
Shuttle Run	.577	.333	.002	.024
Cable Jump	.578	.334	.001	-.124
Twist & Bend	.578	.335	.000	.189

ICSPFT Battery

Variable	Multiple R	R Square	RSQ Change	Simple r
1.5 Mile Run	.319	.101	.101	-.319
Hand Grip	.394	.155	.053	-.239
Pull Ups	.406	.165	.009	-.208

Cooper Test of Aerobic Capacity

Variable	Multiple R	R Square	RSQ Change	Simple r
1.5 Mile Run	.319	--	--	.319

Table 11

Regression of Construct Measures Against
Pass/Fail Criterion in Diving Phase

Variable	Construct	Multiple r	r Square	RSQ Change	Simple r
1.5 Mile Run	Cardiovascular Endurance	.319	.101	.101	-.319
Trunk Twist	Flexibility	.409	.167	.065	.229
Med. Ball Throw	Muscular Power	.460	.211	.044	.289
Purdue Pegboard	Coordination	.485	.235	.023	.312
Balance Roll	Balance	.498	.248	.012	.207
Pull-ups	Muscular Endurance	.506	.256	.008	.208
Isometric Pull	Muscular Strength	.506	.256	.0005	.146

Discussion

Attrition in the diving phase of the EOD program appears to be associated with a set of specific factors. The problem is not one of cognitive competency. Students tend not to fail this phase due to the rigor of classroom requirements. Thus, the ASVAB affords no prediction of final disposition in this phase. The problem seems to be more associated with personal and fitness factors. Correlations of performance with the Adjustment scale of the HPI suggest that those who survive the diving phase are well-adjusted, self-confident and mature. In addition, they tend to be hard working and achievement oriented. Individuals who do not complete the diving phase can be described as immature, anxious, and self-doubting. It seems, therefore, that this phase of training requires substantial physical self-confidence, and, consequently, Adjustment scores from the HPI predict success rather well.

Review of the training regimen for second class divers leaves little doubt that it is a rigorous and physically demanding program. The physical tests most predictive of performance (and therefore most predictive of attrition) were cardiovascular and muscular endurance measures. This suggests that the ability to persist in physical activity and the capacity to withstand fatigue are major factors in successful completion of this phase.

Table 12

Multiple Regression of Psychological and Physical Test Predictors with Pass/Fail Criterion

Variable	Multiple R	RSQ	RSQ Change	Simple R
Diving Phase				
Performance Index	.34	.12	.12	.34
Trunk Twist	.44	.20	.08	.31
Underwater Swim	.51	.26	.06	.23
Swim 300	.56	.32	.07	-.17
Medicine Ball Throw	.61	.38	.05	.28
WK	.64	.41	.04	-.07
Purdue Pegboard	.65	.43	.01	.19
Run 1.5 Mi.	.66	.43	.00	-.22

VI. Summary and Conclusions

Three broad conclusions emerge from this research, and we should emphasize them here. The first is that we have identified a reliable set of predictors of performance during the academic portion of EOD training, and they are valid for all services. This means that we have identified the dispositional determinants of success in the academic part of EOD training. Specifically, the best students are intellectually motivated, self-assured and self-confident, willing to follow rules, and somewhat introverted (in the sense that they enjoy working alone). The correlations here are in the .30 range, but this represents a lower-bound estimate of the correlation, given the noise inherent in our data. In a programmatic sense this means that it is possible for all services to screen potential EOD students with two relatively short and easy to administer test batteries, and in so doing, significantly reduce attrition during the academic portion of EOD training. These two measures are the Self-Directed Search (SDS) and the EOD Performance Index developed from the HPI. The SDS identifies candidates whose vocational interests are compatable with EOD work and the HPI scale indicates those who will succeed in the training.

Our second point is that, for the Navy, success in physical training can be predicted with considerable efficiency at virtually any point during the EOD program. Specifically, it is possible to determine who will attrite during pre-conditioning physical training, and it is possible to predict who is at risk for attrition during diving training. The cardiovascular distance runs are important components in the test batteries. These two portions of the Navy EOD program account for about 70% of the entire attrition; consequently, this finding is tantamount to

solving the Navy EOD attrition problem.

The third conclusion concerns the relevance of this research for actual on-the-job performance as an EOD technician. Our data are based exclusively from student samples; performance during training may not be related to field performance. We can respond to this possibility in two ways. On the one hand, we are presently in the midst of collecting data that bear specifically on this point. We are testing a group of fleet EOD technicians, the members of which have been nominated for competent versus mediocre performance. On the other hand, the results we have presented regarding characteristics of successful EOD students clearly replicate the results presented by Cooper (1982). Cooper tested 40 British bomb technicians, 20 of whom had distinguished themselves by field performance in Northern Ireland. The best technicians were characterized by unconventionality--associated with creative problem solving--and introversion--associated with a preference for working alone. Cooper interprets his findings within a stress management framework that we don't find particularly congenial--in our view, some people simply like the image of themselves as persons competent to perform highly skilled and very dangerous tasks. Cooper's findings, however, fit in well with the data presented in the first part of this report, which suggests that our findings may generalize to actual field performance.

References

American Alliance for Health, Physical Education, Recreation and Dance (1980). Lifetime health related physical fitness. Reston, VA: AAHPERD.

American Alliance for Health, Physical Education, Recreation and Dance (1976). Youth fitness test manual. Reston, VA: AAHPERD.

Astrand, P. O., & Rodahl, K. (1977). Textbook of work physiology, physiological basis of exercise. New York: McGraw Hill.

Baumgartner, T. A., & Jackson, A. S. (1982). Measurement for evaluation in physical education. Dubuque, IA: Wm. C. Brown.

Baumgartner, T., & Zuidema, M. A. (1972). Factor analysis of physical fitness tests. Research Quarterly, 43, 443-450.

Brozek, J., Grande, F., Anderson, J. T., & Keys, A. (1963). Densiometric analysis of body composition: Revision of some quantitative assumptions. Annals of the New York Academy of Science, 110, 113-140.

Clarke, H. H. (1966). Muscular strength and endurance in man. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Cooper, G. L. (1982). Personality characteristics of successful bomb disposal experts. Journal of Occupational Medicine, 24, 653-655.

Cooper, K. H. (1968). Aerobics. New York: Bantam Books.

deVries, H. (1980). Physiology of exercise for physical education and athletics. Dubuque, IA: Wm. C. Brown Publishers.

Durnin, J.V., & Womersly, J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness: Measurements on 481 men and women aged from 16 to 72 years. Journal of Nutrition, 32, 77-97.

Falls, H. G., Ismail, A. M., MacLeod, D. F., Weibers, J. E., Christian, J. E., & Keesler, M. V. (1965). Development of physical fitness test batteries by factor analysis results. Journal of Sports Medicine and Physical Fitness, 5, 185-197.

Fleishman, E. A. (1953). Testing for psychomotor abilities by means of apparatus tests. Psychological Bulletin, 50, 271-262.

Fleishman, E. A. (1964). The structure and measurement of physical fitness. Englewood Cliffs, NJ: Prentice-Hall.

Fleishman, E. A. (1979). Evaluating physical abilities required by jobs. Personnel Administrator, 24, 82-91.

Gough, H. G.(1975). Manual for the California psychological inventory. Palo Alto: Consulting Psychologists Press.

Harris, M. L. (1969). A factor analytic study of flexibility. Research Quarterly, 40, 62-70.

Helson, H. (1949). Design of equipment and optimal human operation. American Journal of Psychology, 42, 473-479.

Hogan, J. C., & Bane, A. L. (1983). Physical and psychomotor tests for surface coal mining jobs. Tulsa: University of Tulsa.

Hogan, J. C., Pederson, K. R., & Zonderman, A. B. (1981). Job analysis and test development for physically demanding Dow Chemical jobs. Baltimore: Johns Hopkins University.

Hogan, J. C., Jennings, M. C., Ogden, G. D., & Fleishman, E. A. (1980). Determining the physical requirements of Exxon apprentice jobs: Job analyses and test development. Washington, DC: Advanced Research Resources Organization.

Hogan, R. (1983). A socioanalytic theory of personality. In M. Page and R. Dienstbier (Eds.), Nebraska Symposium on

Motivation. Lincoln, NE: University of Nebraska Press, 55-89.

Hogan, R. (1984). Manual for the Hogan personality inventory. Minneapolis, MN: National Computer Systems.

Hogan, R. T., Carpenter, B. N., Briggs, S. R., & Hansson, R. O. (1984). Personality assessment in personnel selection. In J. J. Bernardin & D. A. Bownas (Eds.) Personality Assessment in Organizations. NY: Praeger.

Holland, J. L. (1972). Professional manual for the self-directed search. Palo Alto: Consulting Psychologists Press.

Hull, C. H., & Nie, N. H. (1981). SPSS update 7-9. NY: McGraw-Hill.

International Committee for the Standardization of Physical Fitness Fitness Tests. (1974). Basic physical performance tests. In L. Larson (Ed.) Fitness, health, and work capacity: International standards for assessment. NY: MacMillan Publishing Co., Inc.

Ismail, A. M., Falls, H. B., MacLeod, D. F. (1965). Development of a criterion for physical fitness tests from factor analysis results. Journal of Applied Physiology, 20, 991-999.

Jackson, A. S. (1971). Factor analysis of selected muscular strengths and motor performance tests. Research Quarterly, 42, 164-172.

Jackson, A. S., Pollock, M. L., & Ward, A. (1978). Generalized equations for the prediction of body composition. Medicine and Science in Sports, 10, 47.

Johnson, J. A., & Hogan, R. (1981). Vocational interests, personality, and effective police performance. Personnel

Psychology, 34, 49-53.

O'Connell, A. L., & Gardner, E. B. (1972). Understanding the scientific basis of human movement. Baltimore: The Williams and Wilkins Co.

Quigley, A., & Hogan, J. (1982). Patterns of personnel attrition in explosive ordnance disposal training. Tulsa: University of Tulsa.

Robertson, D. (1982). Development of an occupational strength test battery (STB), (NPRDC TR 82-42). San Diego, CA: Navy Personnel Research and Development Center.

Schmidt, R.A. (1971). Proprioception and the timing of motor responses. Psychological Bulletin, 76, 383-393.

Sloan, A. W. (1967). Estimation of body fat in young men. Journal of Applied Physiology, 23, 311-315.

Sloan, A. W., Burt, J. J., & Blyth, C. S. (1962). Estimation of body fat in young women. Journal of Applied Physiology, 17, 967-970.

Tiffin, J. (1960). Purdue pegboard examiner manual. LaFayette. IN: LaFayette Instrument Company.

U.S. Department of Defense. (1980). Armed services vocational aptitude battery (ASVAB) counselor's guide. Ft. Sheridan, IL: Military Enlistment Processing Command.

Wilmore, J. H. (1972). Athletic training and physical fitness: Physiological principles and practices of the conditioning process. Boston: Allyn and Bacon, Inc.

Wilmore, J. H. (1977). Athletic training and physical fitness: Physiological principles and practices of the conditioning process.

Boston: Allyn and Bacon, Inc.

Zuidema, M. A. & Baumgartner, T. (1974). Second factor analysis of physical fitness tests. Research Quarterly, 45, 247-256.

Appendix A

EOD Performance Index

1. I think crowded public events (rock concerts, sports events) are very exciting.
2. As a child, I was always reading.
3. Happiness is more important than fame.
4. I en[illegible]ing people feel better.
5. I rem[illegible] phone numbers easily.
6. I like classical music.
7. I expect to succeed in things I do.
8. I am always arguing with people.
9. In school I didn't like math.
10. I don't pay attention to how I look.
11. I enjoy solving riddles.
12. Being part of a large crowd is exciting.
13. I try to do my job as well as I possibly can.
14. I would like to know more history.
15. I enjoy reading poetry.
16. Everyone has some good qualities about them.
17. I can't do anything well.
18. In school, I memorized facts quickly.
19. I read at least ten books a year.
20. I like to talk to people.
21. As a child, school was easy for me.
22. I enjoy working crossword puzzles.
23. I was a slow learner in school.
24. I have a large vocabulary.
25. I don't enjoy a game unless I win.

26. I would rather read than watch tv.

27. In school I am/was usually in the upper part of my class.

28. I never go out of my way to help others.

29. I have taken things apart just to see how they work.

30. I can do long division in my head.

31. I like to hear lectures on world affairs.

32. If something is worth doing, it is worth doing well.

33. I think I would like to do research.

34. In school, math was easy for me.

35. I find Greek mythology interesting.

36. I would volunteer for an Army drug experiment.

37. I have a lot of friends.

38. I love the hustle and bustle of city crowds.

39. I am a fast reader.

40. I am a good speller.

41. I hate opera singing.

42. I like to play chess.

43. I am interested in science.

44. I can multiply large numbers quickly.

45. I like detective stories.

46. I enjoy just being with other people.

47. Nothing seems to matter to me anymore.

48. I can use a microscope.

49. I understand why stars twinkle.

50. I am a sociable person.

51. I have a good memory.

52. I enjoy meeting new people.

53. Basically, I am a cooperative person.

54. I would like to be an inventor.

55. My successes mean little to me.

56. I don't care for large, noisy crowds.

57. I'm pretty careful in my work.

58. I would rather work with facts than people.

Appendix B

Description and References for Physical Tests

The skinfold measurement is assessed with the Skyndex electronic calipers at the biceps, tricepts, subscapulae, and illiac crest, using the Durnin formula. The final score is the percentage of total body weight that is fat (AAHPERD, 1980).

The Purdue Pegboard is a commercially manufactured test of manual dexterity, consisting of the manipulation of pins, collars, and washers on a pegboard with the right hand, left hand and both hands. Scoring consists of the number of pins inserted in the pegboard within the 30 or 60 second time limit (Tiffin, 1960).

The balance rail is a measure of static balance requiring the individual to balance with one foot on a 3/4" rail, hands on hips, and eyes closed. Scoring is the amount of time (to the nearest tenth of a second) that the balance can be maintained on two separate trials (Fleishman, 1964).

The rolling board is a measure of balance; the participant must stand on the board that is straddled over a short log. Each of the two trials begins when the person is balanced, and is timed in seconds until either side of the board touches the ground.

The speeded twist and bend tests neuromuscular coordination. The participant stands with back to the wall, and alternates touching the floor between the feet, then straightening up and twisting around to touch an "X" marked on the wall behind the back at shoulder blade height. The score is the number of times the participant touches the wall in 20 seconds (Fleishman, 1964).

The trunk twist assesses trunk flexibility, requiring the participant to stand with one side to the horizontal chart on the wall, arms at shoulder height, and to rotate clockwise as far as possible. The score of both trials is recorded in inches; a 180° twist is read as 12 inches, greater rotation results in a higher score (Fleishman, 1964).

Grip strength is measured using a Smedley grip dynometer. Scores of both trials are measured in kilograms using the dominant hand, (Fleishman, 1964, ICSPFT, 1974).

The pull test measures muscular strength. It is administered using a Dillan Dynamometer chained to an immovable post at waist height. Participants are positioned correctly to exert a maximum horizontal pull on the dynamometer handle. Each of the three pulls is recorded to the nearest 10 pounds (Hogan, Zonderman, & Pederson, 1981).

The lift test is a measure of static strength. The participant is instructed to use proper lifting techniques and exert a maximum vertical pull against the handle and dynometer anchored to a platform. The three pulls are recorded to the nearest 10 pounds (Hogan, Zonderman, & Pederson, 1981).

The standing long jump assesses muscular power of the legs. The participant jumps as far as possible from a standing start in each of three trials. Score is the distance jumped (in inches) from the take off line to the point of contact of the heels (AAPHERD, 1976).

The medicine ball throw tests muscular power. The participant stands with both feet on the ground and throws a 18 lb. ball as far as possible, using one hand (shot-put style). The score for each of three trials is read in inches from the measuring tape secured to the ground (Fleishman, 1964).

The cable jump assesses neuromuscular control by requiring the participant to jump over a length of rope held between the hands. The score is the number of successful jumps computed in five trials (Fleishman, 1964).

The pull-up measures muscular endurance of the upper body. The participant uses an overhand grasp to perform as many consecutive chin-ups as possible (AAPHERD, 1976; Fleishman, 1964; and ICSPFT, 1974).

Modified sit-ups which assess abdominal strength and endurance are performed with bent knees, and arms crossed over the chest. Scoring is the number of sit-ups completed in 60 seconds (AAPHERD, 1980; AAPHERD, 1976).

The arm ergometer test measures upper body endurance by requiring the participant to crank two handles set at a resistence of 50 watts. The score is the number of revolutions completed in 90 seconds (Hogan, Jennings, Ogden, & Fleishman, 1980).

The vertical jump measures the distance between standing reach and maximum height jumped in 3 trials. Muscular power is determined from a nomogram based on inches jumped and body weight (ICSPFT, 1974; Mathews & Fox, 1976).

The sit and reach test is a measure of flexibility in the lower back and legs. From a sitting position the participant stretches forward and reaches along a meter stick; 0 cm is even with the knees, and 23 cm is even with the feet (AAPHERD, 1980).

Push-ups are a measure of upper body endurance. Scoring is the number of correct push-ups (feet, hips and shoulders lined up) performed consecutively (Robertson, 1982).

The shuttle run is a measure of muscular power. The participant must run 30 feet, pick up a block, turn, run back, put it down and then repeat again as quickly as possible. Each of the two trials is timed to the nearest tenth of a second (AAPHERD, 1976; Fleishman, 1964).

The 50 yard dash assesses explosive strength and power. From a standing start, both trials are timed to the nearest tenth of a second (AAPHERD, 1976; ICSPFT, 1974).

The 1½ mile, 1 mile and 600 yard run each measure cardiovascular endurance. One trial is given for each distance; time is recorded to the nearest second (AAPHERD, 1980; AAPHERD, 1976; Cooper, 1968; Fleishman, 1964; ICSPFT; 1974).

The 300 yard swim assesses cardiovascular endurance, requiring the participant to cover the 12 lengths of a 25 yard pool as quickly as possible.

The underwater swim is a measure of anaerobic capacity. Each participants pushes off the wall and swims as far as possible underwater. The markers along the side of the pool (measured in feet) are used to determine the total number of yards swum.

Appendix C

Physical Testing Variables

Physical Testing Variables

Fitness Test	Units of Measurement	Computed Score
1 Mile Run	Min.	Trial 1
1-1/2 Mile Run	Min.	Trial 1
600 Yd. Run	Min.	Trial 1
300 Yd. Swim	Min.	Trial 1
Underswim	Yds.	Trial 1
Grip Str.	Kg.	(Trial 1 + 2) /2
Pull Str.	lbs.	(Trial 1 + 2 + 3) / 3
Lift Str.	lbs.	(Trial 1 + 2 + 3) /3
Med. Ball	Inches	(Trial 1 + 2) /2
Push-up	Number	Trial 1
Pull-up	Number	Trial 1
Arm Ergom.	Number	Trial 1
Shuttle Run	Sec.	(Trial 1 + 2) /2
Long Jump	Inches	(Trial 1 + 2 + 3) / 3
50 Yd. Dash	Sec.	(Trial 1 + 2) /2
Vert. Jump	Inches	(Trial 1 + 2 + 3) /3
Cable Jump	Number	(Trial 1 + 2 + 3 + 4 + 5)
Sit-ups	Number	Trial 1
Twist Bend	Number	Trial 1
Sit & Reach	Cm.	(Trial 3 + 4) /2
Trunk Twist	Inches	(Trial 1 + 2) /2
Balroll	Sec.	(Trial 1 + 2) /2
Balrail	Sec.	(Trial 1 + 2) /2
Weight	lbs.	Trial 1
Height	Inches	Trial 1
Pct /Fat	Percent	Trial 1

Appendix D

Diving Phase Performance Index

1. Sometimes I feel like a failure.
2. Happiness is more important than fame.
3. I am confused about what I want to be.
4. I shouldn't do many of the things I do.
5. In a group of people, I usually do what the others want.
6. I sometimes feel like I am watching myself.
7. I enjoy making people feel better.
8. Sometimes I feel like I'm going to fall apart.
9. There are a lot of things I would like to change about myself.
10. I expect to succeed in things I do.
11. I get excited very easily.
12. I feel guilty about some of the things I have done.
13. I am always arguing with people.
14. I am a very self-confident person.
15. I wish I knew what I wanted out of life.
16. I don't care if others like the things I do.
17. I don't pay attention to how I look.
18. I'm always tired.
19. I get nervous if I think someone is watching me.
20. I don't mind talking in front of a group of
21. I am uncomfortable entering a room full of people.
22. I don't really care what other people think of me.
23. In school I found it hard to talk in front of the class.
24. I try to do my job as well as I possibly can.

25. I would like to know more history.

26. Most of the time I am proud of myself.

27. I sometimes wish I were somebody else.

28. I often feel anxious.

29. I am seldom tense or anxious.

30. The future seems hopeless to me.

31. Everyone has some good qualities about them.

32. I frequently have indigestion.

33. Many people would say that I am shy.

34. I can't do anything well.

35. I get out of breath more easily than I used to.

36. Nothing good ever happens to me.

37. I often think about the reasons for my actions.

38. I'm uncertain about what to do with my life.

39. I don't enjoy a game unless I win.

40. I am almost always too hot or too cold.

41. I never go out of my way to help others.

42. I worry a lot.

43. I often wonder about how I got to be the way I am.

44. I get depressed a lot.

45. I have taken things apart just to see how they work.

46. Other people's opinions of me are not important.

47. I frequently have headaches.

48. I like to hear lectures on world affairs.

49. It often seems that my life has no meaning.

50. If something is worth doing, it is worth doing well.

51. I find it hard to act naturally when I am with new people.

52. I have a hard time making choices and decisions.

53. I like what I do for a living.

54. I have little self-confidence.

55. I would volunteer for an Army drug experiment.

56. I feel like life is just passing me by.

57. I keep calm in a crisis.

58. I often feel that I chose the wrong occupation.

59. Nothing seems to matter to me anymore.

60. I rarely get anxious about my problems.

61. I often try to understand myself.

62. There are a lot of things I would like to change about my past.

63. I am a happy person.

64. I often analyze my motives.

65. I am usually calm.

66. Basically, I am a cooperative person.

67. My successes mean little to me.

68. My health is excellent.

69. I'm pretty careful in my work.